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COMPARATIVE PERFORMANCE ANALYSIS OF MACHINE LEARNING TECHNIQUES FOR CARDIOVASCULAR DISEASE PATTERN DETECTION

Abstract: *this paper evaluates the performance of three data analysis techniques-decision trees, neural networks, and self-organizing Kohonen maps-in identifying cardiovascular disease patterns. Based on a dataset of 1,328 patient records, the models were compared regarding classification accuracy for target variables and demographic attributes. The neural network achieved the lowest error rate for disease prediction (3.61%), while the decision tree showed robust performance (6.17%) with higher interpretability. The findings underscore the necessity of method selection based on data specificity and the trade-off between accuracy and transparency in medical diagnostics.*

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Keywords: *data analysis, machine learning, decision trees, neural networks, Kohonen maps, healthcare analytics.*

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ЭФФЕКТИВНОСТИ МЕТОДОВ МАШИННОГО ОБУЧЕНИЯ ДЛЯ ВЫЯВЛЕНИЯ ПАТТЕРНОВ СЕРДЕЧНО-СОСУДИСТЫХ ЗАБОЛЕВАНИЙ

Аннотация: *в статье проводится оценка эффективности трех методов анализа данных – деревьев решений, нейронных сетей и самоорганизующихся карт Кохонена – для выявления паттернов сердечно-сосудистых заболеваний.*

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На основе набора данных, включающего 1 328 записей о пациентах, модели сравнивались по точности классификации целевых переменных и демографических атрибутов. Нейронная сеть продемонстрировала наименьший уровень ошибки при прогнозировании заболевания (3,61%), в то время как дерево решений показало надежные результаты (6,17%) при более высокой интерпретируемости. Полученные результаты подчеркивают необходимость выбора метода с учетом специфики данных, а также компромисса между точностью и прозрачностью моделей в медицинской диагностике.

Ключевые слова: *анализ данных, машинное обучение, деревья решений, нейронные сети, карты Кохонена, медицинская аналитика.*

Introduction: data analysis has become an indispensable tool in healthcare for identifying patterns, predicting trends, and discovering internal dependencies within multivariate patient records. This study focuses on the application of three powerful ML techniques: decision trees, neural networks, and self-organizing Kohonen maps (SOM). The objective is to reveal their effectiveness in uncovering hidden dependencies related to heart disease and to provide concrete practical examples of their application in solving real-world diagnostic problems.

Research Methods: the dataset comprises 1,328 records, each representing a patient with 14 medical attributes, including age, sex, chest pain type, resting blood pressure, serum cholesterol, and maximum heart rate. The target variable indicates the presence (1) or absence (0) of heart disease.

- *Decision Trees:* Provide a transparent, hierarchical decision structure that simplifies result interpretation and identifies key factors affecting classification.

- *Self-Organizing Maps (SOM):* Employed to cluster patients based on multidimensional clinical characteristics, facilitating the visualization of data structures and grouping of similar profiles.

- *Neural Networks:* A multilayer architecture was utilized to automatically extract meaningful features and minimize prediction errors for complex, non-linear relationships in the medical data.

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Results and Discussion: the models were evaluated based on their error rates in predicting the target variable (disease presence), age, and sex.

- *Decision Tree:* Demonstrated high performance in predicting the target attribute (error rate 6.17%) and sex (5.12%). However, a 0% error in age prediction suggests potential overfitting to the training data.

- *Kohonen Maps:* Encountered difficulties with categorical and continuous variable predictions, yielding a 10.71% error for the target and 50.15% for age, indicating the need for rigorous parameter tuning.

- *Neural Network:* Showed the best overall performance for disease prediction with an error rate of 3.61%. Nevertheless, it struggled with age determination (99.62% error), highlighting the necessity for architectural optimization when handling diverse attribute types simultaneously.

The varying sensitivity of the methods to different attributes emphasizes the importance of understanding data specificity. Decision trees excel in identifying transparent dependencies affecting heart disease risk, while neural networks provide superior classification accuracy for the primary diagnostic target.

Conclusion: the comparative analysis confirms that no single algorithm is universally optimal for all medical attributes. Decision trees offer a balance of acceptable accuracy and high interpretability, crucial for clinical decision support. Neural networks provide superior predictive power for the target disease but require careful tuning to handle auxiliary demographic variables. Future research will focus on ensemble methodologies to mitigate overfitting and improve multi-target prediction accuracy.

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